AMERICAN LOBSTER (*Homarus americanus*) AQUACULTURE DEMONSTRATION PROJECT AT THE NATURAL ENERGY LABORATORY OF HAWAII

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INTRODUCTION

From September 1982 to September 1983, Sanders Associates, Inc. of Merrimack, New Hampshire, was involved in an aquaculture demonstration project at the Natural Energy Laboratory of Hawaii (NELH), which is located at Keahole Point, Hawaii. The species of study was the American lobster *Homarus americanus* (Figure 1).

By mid-1982, Sanders Associates had completed a 5-year culture research effort and a 2-year developmental program with the American lobster in Kittery, Maine, and in Nashua, New Hampshire, respectively. In addition, Sanders Associates' personnel and equipment were used to conduct a concurrent 15-month site validation and technology demonstration at Amfac's International Shellfish Enterprises Facility in Moss Landing, California. The 7-year experimental and pilot programs resulted in the development of a licensable technology package for the culture of the American lobster. This effort included the review of more than 2,600 technical documents, spanning 121 years. The resultant license package includes unique and proprietary systems and hardware designs, proprietary husbandry and business management technology data, four patents issued with one patent pending, and more than 250 special operating procedures.

Site selection analysis conducted by Sanders Associates during 1982 indicated that there are a limited number global locations where ambient conditions might be appropriate for commercial culture of the American lobster. The analysis showed that Hawaii is the only U.S. location with potential because it has year-roundseawater temperature, which requires little or no modification for culturing the American lobster.

Flow-through culture systems could be used, eliminating the need for much equipment. Simple, flow-through culture systems greatly reduce equipment costs, building size, and energy costs. Additionally, flow-through operations should allow higher operating temperatures with minimal water quality problems, potentially yielding higher growth rates.

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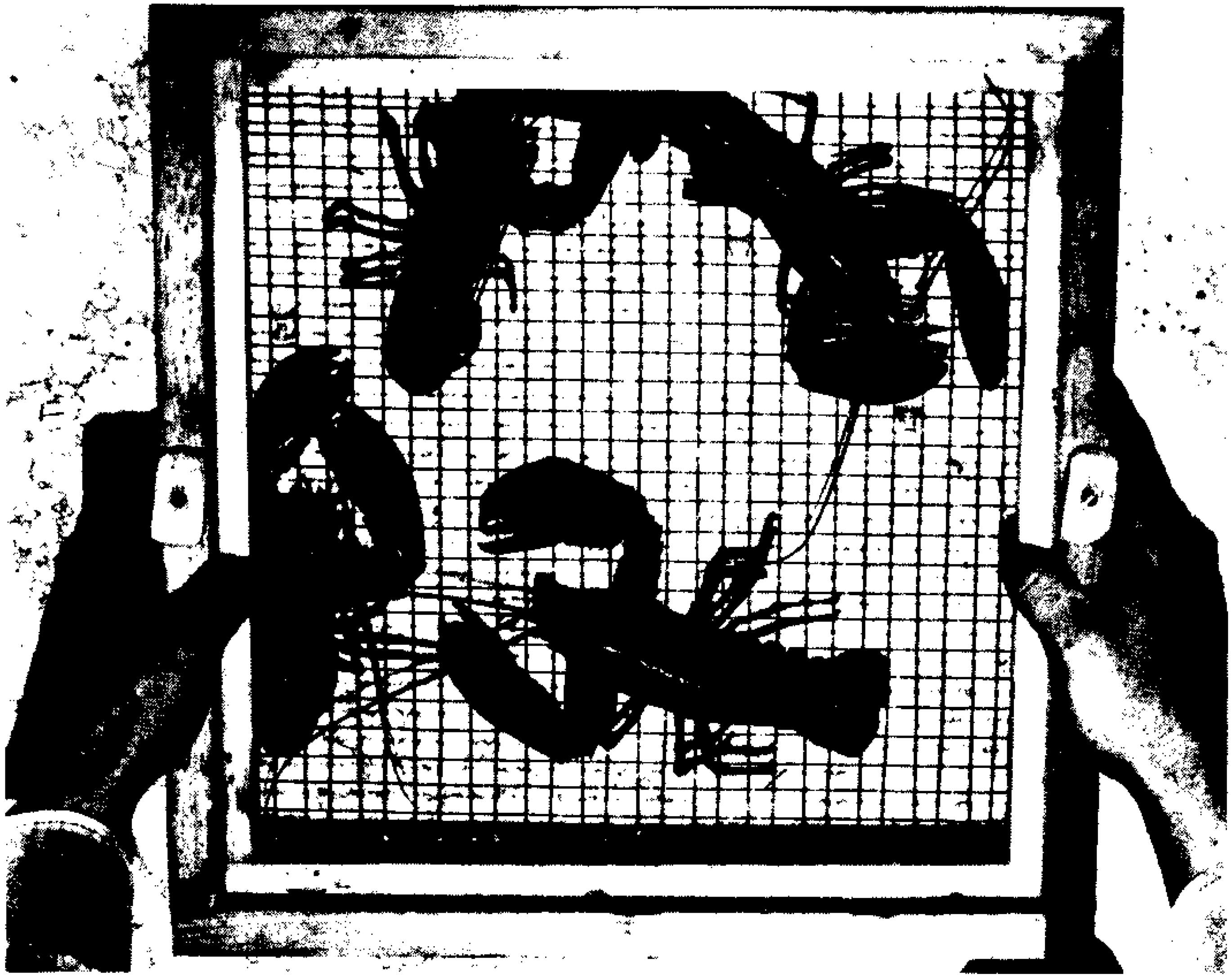

Figure 1. The American lobster Homarus americanus cultured in captivity. (Photo courtesy of California Sea Grant College Program)

PROJECT SITE VALIDATION

During 1982, Sanders Associates entered into a cost-sharing agreement with the state Department of Planning and Economic Development for a site verification and demonstration of the American lobster culture system at NELH. The site verification, which should precede any commercial venture, was conducted to determine: (1) growth and survival relationships for all stages and seasons under ambient conditions; (2) cost and logistics factors for locally produced diets which use indigenous fisheries by-products; and (3) a refined site-specific business plan.

The primary requirements for the successful culture of any species are (1) an appropriate which duplicates or enhances the animal's natural habitat; and (2) a nutritious food, which is accepted by the animal, has properties suitable for use in a culture system and supports acceptable growth and survival rates. These keystones must be economically compatible with a business model. Included in the environmental consideration is the elimination or control of unwanted biofouling organisms, which may inhibit the growth of a cultured species or seriously affect system operation and maintenance.

PROJECT GOALS

Sanders Associates' goals for the demonstration project were:

1. To assess the suitability of ambient seawater at NELH for the culture of American lobster
2. To determine optimal operating conditions for a Hawaii-based flow-through culture system for the American lobster
3. To modify and evaluate the existing lobster diet recipe for a least-cost Hawaii-based formulation
4. To determine specific growth and survival rates, costs, and market factors for the Hawaiian location
5. To revise the initial Hawaii pro-forma financial analysis to reflect site verification findings
6. To seek investors for a Hawaii-based lobster culture venture under license to Sanders Associates

MATERIALS AND PROCEDURES

By September 1982, we located all the necessary culture equipment to NELH. The demonstration equipment included a 20 ft x 50 ft inflatable building (Figures 2 and 3), a broodstock holding system, a larval hatching and rearing system, a postlarval rearing station, 24 MOD II growout tanks, and a 72-basket MOD III growout demonstrator (Figure 4). Figure 5 shows the orientation of the lobster project relative to other OTEC aquaculture projects.

Sanders Associates' aquaculture team, assisted by NELH personnel, installed the building, equipment, and associated internal plumbing. Since the inflatable shelter was originally designed for hydroponics, it had to be modified for our aquaculture application. These modifications included installation of a 92% agricultural sunscreen over the shelter to reduce heat build-up and system

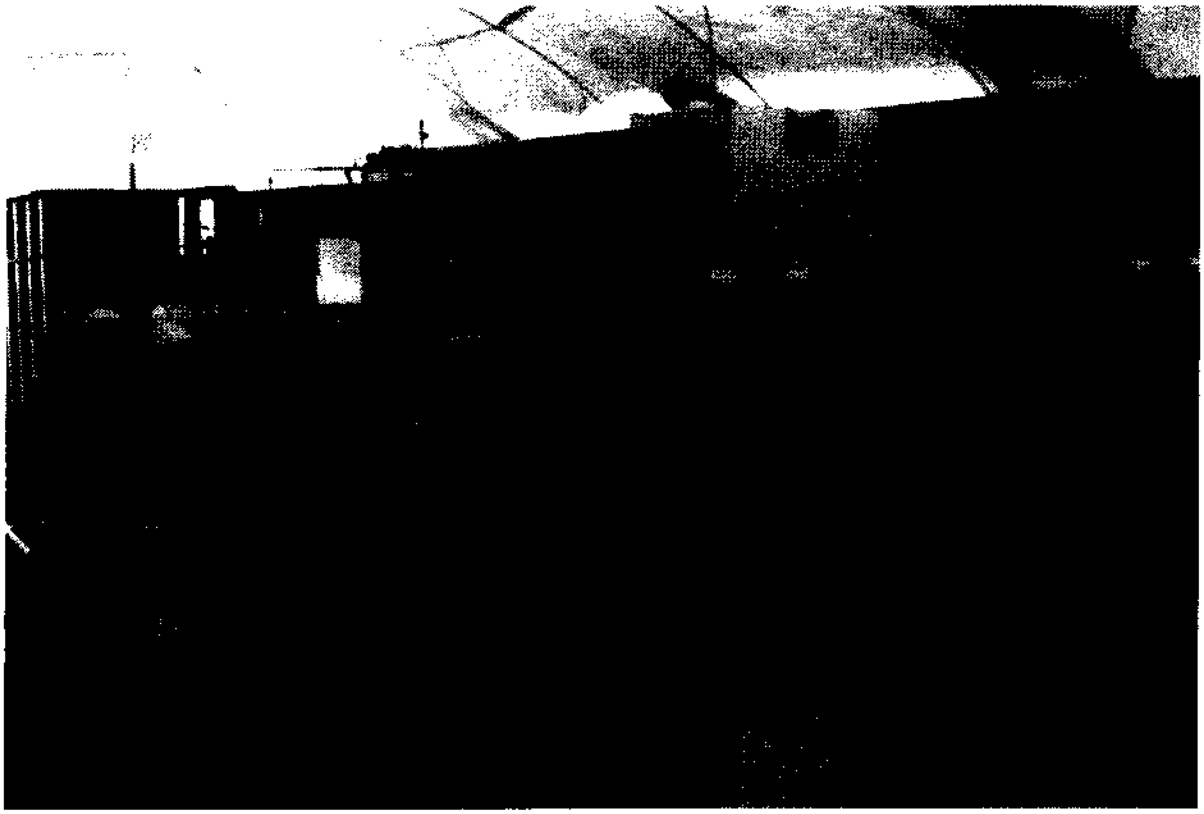

Figure 2. The inflatable 20 ft x 50 ft building to the left housed the lobster aquaculture demonstration project from September 1982 through September 1983. The tanks in the foreground contain seaweed under cultivation, and the storage tank in the background is associated with an abalone demonstration project.

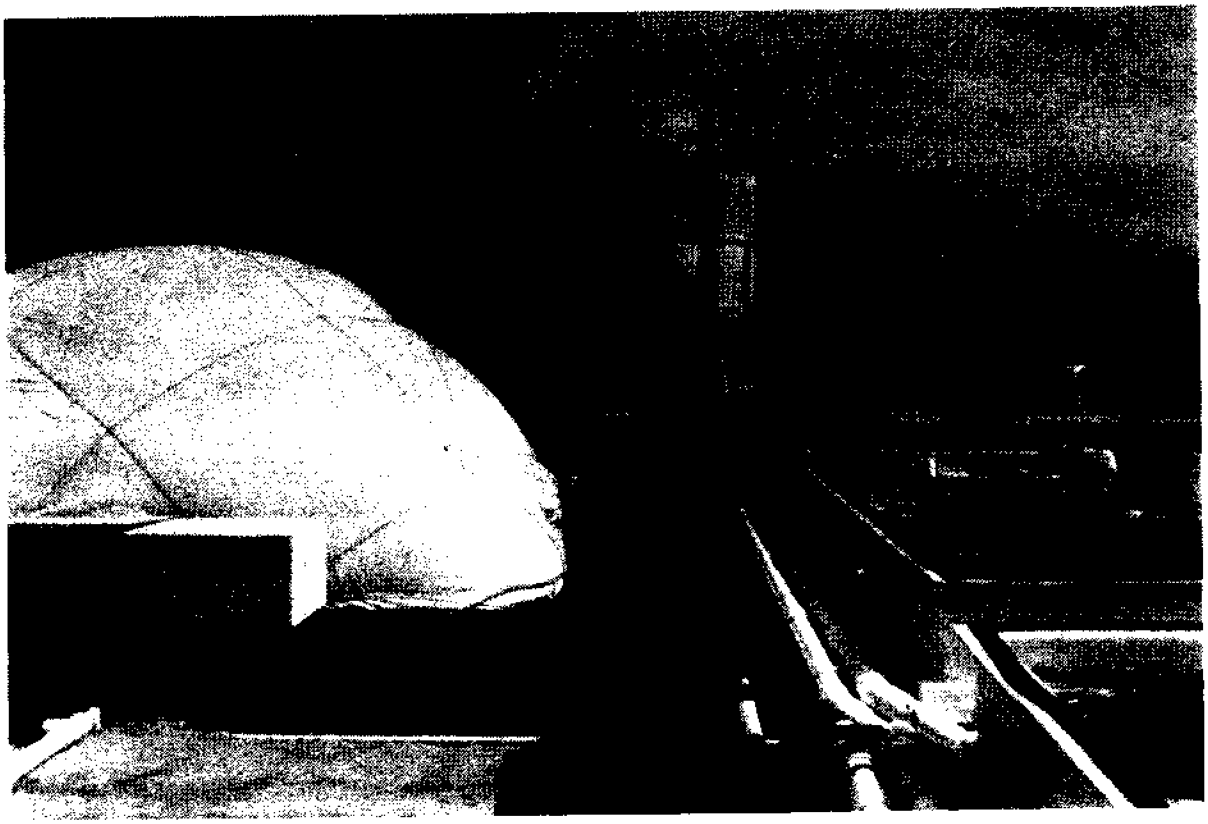

Figure 3. Inside the inflatable building are the larval system with sump pump and filter (immediate foreground), the hatching car (the square box on top of the larval system), the postlarval system (aquarium-like structure behind the larval system), and the growout system tanks (left background).

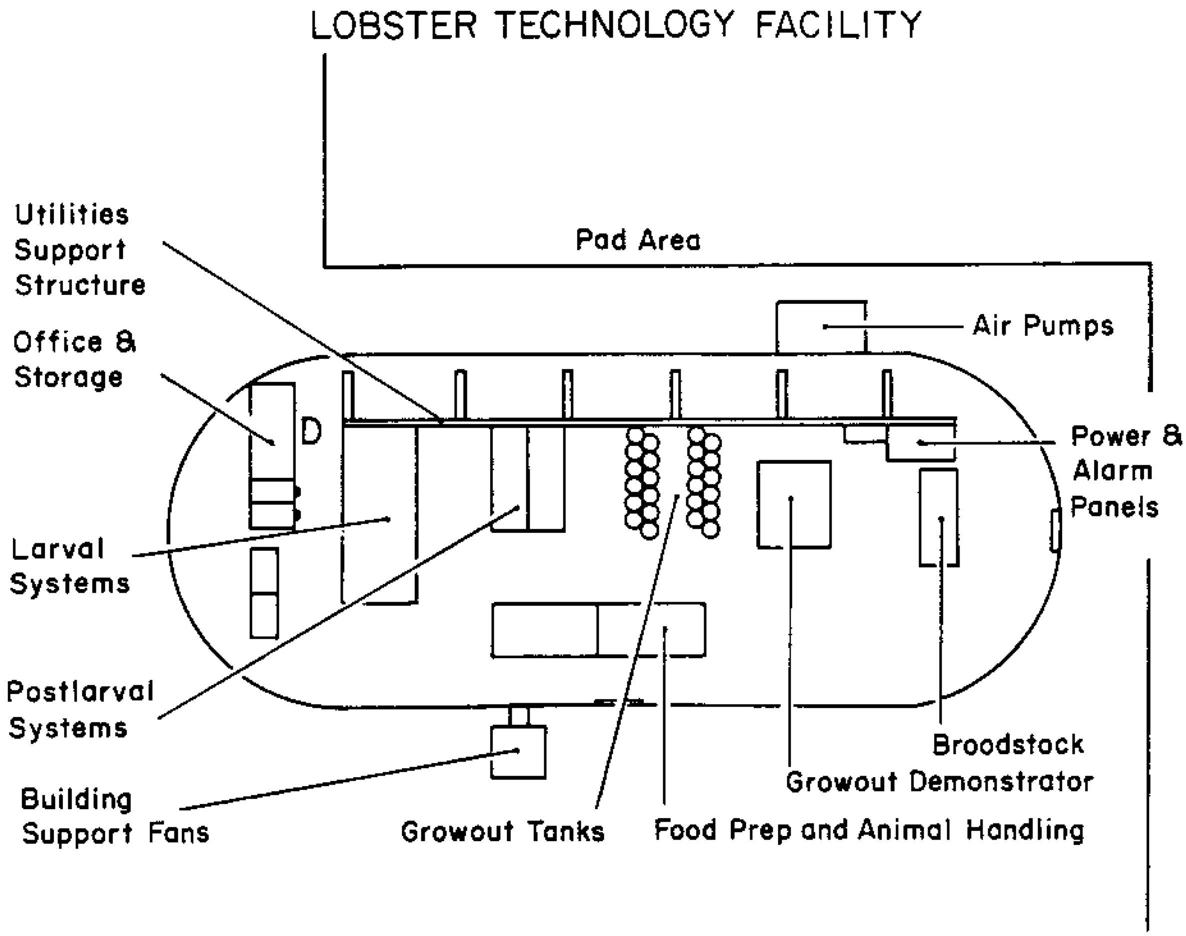

Figure 4. Layout of lobster culture equipment inside the 20 ft x 50 ft inflatable building used for site verification at the Natural Energy Laboratory of Hawaii

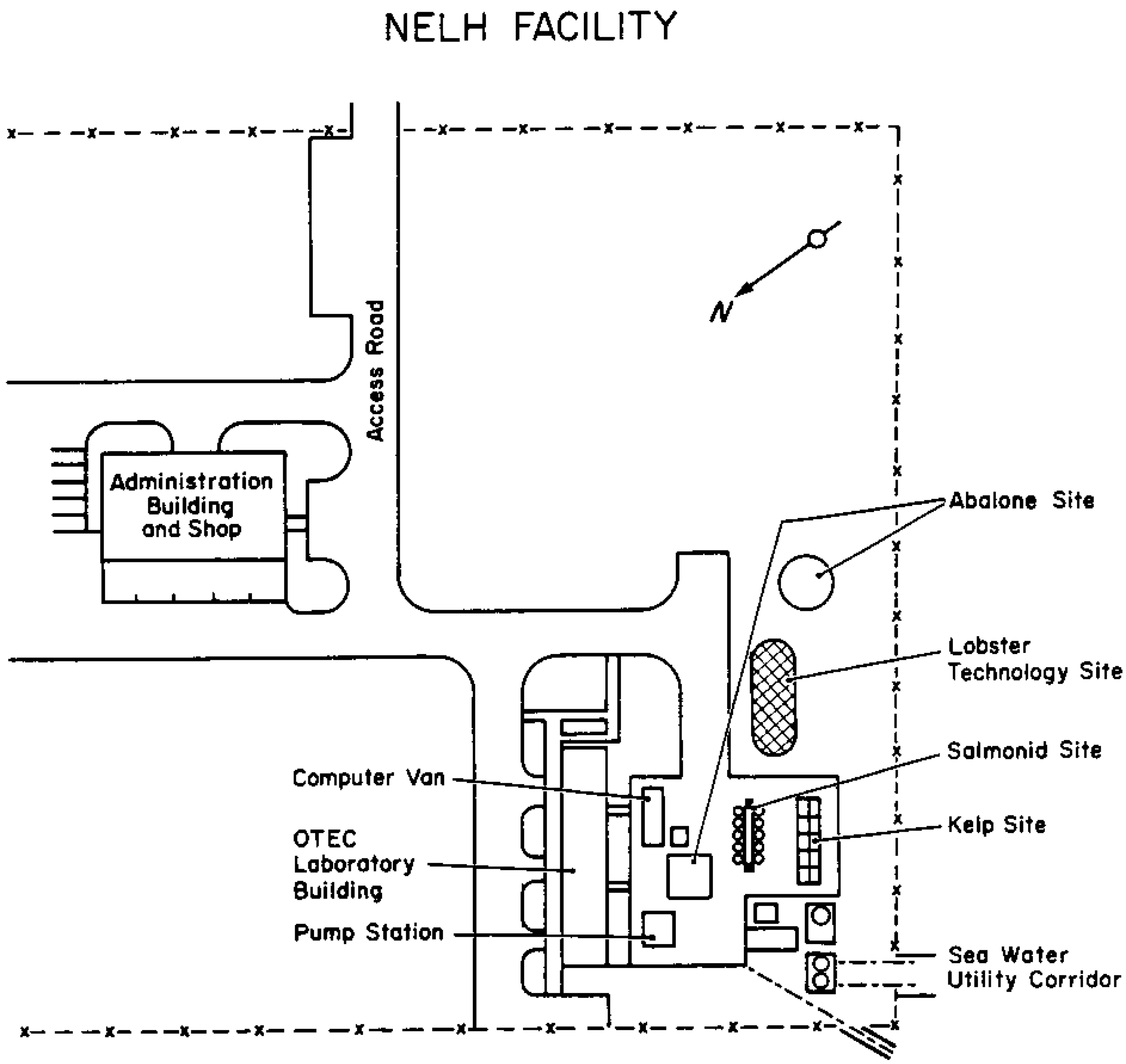

Figure 5. OTEC aquaculture site layout at the Natural Energy Laboratory of Hawaii during 1982–83

biofouling and installation of a quieter blower. Because of the permeability of the crushed lava and coral building pad, special precautions were required to maintain building inflation air pressure.

After installation of the shelter and other culture equipment, 1,500 postlarval, 2,000 juvenile, and 6 adult lobsters were shipped from Sanders Associates' Moss Landing site; 10 "berried" females were shipped from the U.S. East Coast. The lobster culture stock shipped to NELH comprised the full spectrum of animal sizes and growth stages. The lobster population at NELH fluctuated between 2,000 and 6,000 animals during the 12-month test period.

The first Hawaii hatch of over 16,000 larvae occurred in January 1983, and the next four hatches occurred in overlapping intervals from April 1 to May 1, 1983, and again from May 21 to June 10, 1983. These hatches resulted in of animals beyond available facility capacity. The postlarval system was filled to capacity from these hatches when the animals reached the appropriate size. Surplus lobster were shipped to the mainland in accordance with the covenants of the Hawaii import permit. Animals from the later hatches remained in the culture system at NELH until the project was terminated and provided valuable growth and survival data.

Lobster survival, growth, feed conversion, and other pertinent data were collected throughout the test period. Water quality was monitored daily. These data were compared with data collected at previous research sites operated by Sanders Associates.

CONCLUSIONS AND RECOMMENDATIONS

Water Conditions

Ambient surface seawater temperatures in Hawaii are above the optimal level for lobster culture and are especially lethal during the summer months. A viable American lobster production operation in Hawaii would require either pumping from a cool saltwater well or a continuous mixing of deep and surface waters to provide a workable operating temperature. The following list summarizes culture considerations.

1. The optimum temperature was 20°C ± 1°C.
2. Minimum water flow rates for acceptable water quality are substantially lower for a flow-through system in Hawaii than those normally required for closed, recirculating systems in colder climates.
3. NELH water has negligible concentrations of chemicals toxic to American lobster (i.e., NH_3, PO_4, NO_2).
4. NELH surface water contained many species of biofouling organisms and had relatively low bacteria counts and was rich in nutrients.
5. The mixing of deep and surface waters encouraged blooms of both bacteria and biofouling organisms under full sunlight. This can be controlled satisfactorily with shade cloth or some other opaque material.
6. Surface water at NELH had a high dissolved oxygen content. The cold deep water (8°C to 12°C) contained inadequate dissolved oxygen and required intensive aeration. Mixing surface and deep waters provided a satisfactory solution.

Half of the initial culture tests at NELH was conducted using ambient surface waters; the other half was controlled at 20°C ± 1°C by blending OTEC deep and surface waters. This test scheme was used because we found high mortality rates at temperatures greater than 22°C. Losses occurred at the higher temperatures because of excessive metabolic rate among the lobster and because of biofouling. The biofouling was corrected by covering the growout system with an opaque shroud to reduce the light level. Biofouling can also be effectively controlled by using well water or a mixture of surface and deep waters resulting in lower than ambient temperatures and lower nutrient concentrations. High water temperature, rather than biofouling constituted the major stress factor. Subsequently, the operating temperatures in all growout systems were reduced to 20°C, except for a "control" which was kept at ambient temperature to confirm our initial findings.

Culture Trials

Animals were successfully mated at the NELH test site. However, the test period ended before egg extrusion and hatching could occur.

The ambient photoperiod at NELH promoted rapid egg development, even with broodstock held at lowered temperatures. This could be beneficial and easily accommodated. Survival in the postlarval system was good using mixed surface and deep waters at 20°C.

At reduced operating temperatures (20°C ± 1°C), the MOD III growout demonstrator gave high survival rate and was suitable equipment for growout. It is easy to maintain and allows for reduced animal handling, as well as reduced environmental stress and injury to animals.

Although animal mortalities with the Hawaii diets at 20°C temperature were acceptable, the growth rates were not. Growth was less than required for a viable commercial venture. In addition, the cost of locally available ingredients was too high.

Waste Solids and Water Disposal

A commercial production site in Hawaii with high water usage may require costly water treatment or injection wells for effective wastewater disposal. Tests conducted at NELH, however, showed that tilapia readily thrive on system detritus and uneaten lobster food. This may be a cost-effective alternative means of reducing water treatment costs, while providing another cash crop.

Achievability, Marketing, and Venture Development

From a technical standpoint, American lobster culture could be accomplished in Hawaii. The required system modifications and operating mode changes, however, appear to be far more costly than initially anticipated. The apparent advantages of the year-round higher ambient water temperature may not compensate for these other constraints.

The relatively small local market for American lobster would consume only a portion of the production necessary to justify a commercial lobster venture in Hawaii. The Hawaii market is currently being serviced adequately from U.S. East Coast sources at competitive retail prices. Most of the lobsters produced in Hawaii would have to be exported, but it is questionable whether this could be done at a profit.

The culture of American lobster could benefit by being combined with the culture of other species in a synergistic way. This would spread the risk, provide earlier cash flow and the stability of a multiproduct businessresulting in a venture economically which is viable. Tilapia is a logical candidate species, as are oysters and some seaweeds. Each species would be held in a separate system operated at its own best condition, but each would use by-products from the other operations. Administrative and marketing costs would be shared.

Based on our findings, we do not recommend the single species culture of the American lobster in Hawaii at this time.